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**Notes on Thinning in
Plantations**

by

C. K. Homfray, B.A., I.F.S.

Deputy Conservator of Forests, Silviculturist, Bengal

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NOTES ON THINNING IN PLANTATIONS.

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Notes on Thinning in Plantations.

General.

The necessity has been felt for a note on the thinning of different species put out in plantations, in order to act as a rough guide as to the number of stems to be left per acre at different ages under the type of thinnings at present being carried out. It must be clearly understood that this note is purely in the nature of advice. It only embodies the opinion and experience of the writer obtained from observations and data collected from thinning Sample Plots, and from selected sample counts in plantations taken by the Silvicultural and Divisional staff, and lays down no rules as to the most suitable type of thinning for any one species.

The number of trees per acre from selected Sample Plots and countings were plotted against age and a smooth curve drawn through them. The average height at different ages was also obtained by plotting heights of dominant trees only against age for the same selected plots and countings and drawing a smooth curve. The number of trees per acre at any age refers to dominant trees only except in the case of the first thinning in *sal* (*Shorea robusta*) where all trees are included. From the tables giving the number of trees per acre for each species at different ages it should be possible for the Range Officers to do a sample half-acre on these figures and so get some idea as to the required density of the thinning, but it should be clearly understood that if the average height of the dominants is less than that given for the same age in these notes then more trees per acre will have to be left and *vice versa*. In this connection it is to be remembered that the figures given for number of trees

per acre refer to fully stocked crops with no blanks and to plantations where thinning has been done in time and not delayed.

The grades of thinnings referred to are those laid down as standard in the Indian Forest Records, Silvicultural Series, Vol. XV, Part I, "Classification of thinnings."

A table giving the number of trees per acre at different spacing in multiples of 4' and 6' is given at the end of these notes as a ready reference. This is included in order to give thinning officers a rough idea of the spacing corresponding to the number of trees per acre given in the tables.

Removal of suppressed and dominated stems.

The question of the removal of suppressed and dominated stems in thinnings is still a very debatable point. As regards *sal* the present order is for the removal of all suppressed and badly dominated stems as experience up-to-date shows that in most cases dense shade encourages the growth of the worst species of climbers, and that the cutting of the suppressed stems greatly assists in climber-cutting which becomes both cheaper and more effective. Experience also shows that thinning is rendered quicker and more efficient by the removal of suppressed and dominated stems by coolies working ahead of the marking officer, as subordinates find it very difficult to do a crown-thinning only in congested lines of *sal* especially the first thinning. Again it is suggested that if the object in burning *sal* plantations is to change soil conditions, direct sunlight will be necessary, and that in fact burning without reducing shade does little more than change the vegetation to a more fire resistant type without affecting the soil and for this reason also it is desirable to remove dominated and suppressed stems so as to get light to the ground.

In plantations of miscellaneous species the question of removal of suppressed and dominated stems has not been fully investigated. Plots laid out three years ago in *pānisaj* (*Terminalia myriocarpa*) at Chunbhati, Chel Range, Kalimpong Division, to see whether heavy thinning encourages the growth of climbers show up-to-date that there are more climbers in the unthinned plot, where they are mostly confined to the suppressed stems and from them passed on to the stems in the higher canopy. The question of letting in light after burning does not arise here, but nevertheless free circulation of air must have a beneficial effect and a dense suppressed under-growth cannot make for healthy conditions. Again suppressed stems not putting on any growth are sickly and will probably be the cause of fungal and insect pests. The removal of suppressed and dominated stems besides being a question of silviculture is also one of finance. If line-sowing has been dense then it will probably help in ease and quality of thinning to remove such stems, whereas in the case of *thali*-planting such removal will not help and is not necessary. Again in some areas near Tea Gardens the produce from thinnings of all ages is saleable, and in such cases the writer is of the opinion that suppressed and badly dominated stems should be removed as these usually do not put on any increment and their removal will make way for the natural introduction of other species suitable for fuel and timber. With exotic species especially *teak* (*Tectona grandis*) and certain indigenous ones such as *gamar* (*Gmelina arborea*), which are prone to innumerable diseases which may become epidemic, the removal of suppressed and dominated stem is imperative as such diseases are spread from these stems that are sickly and have not proper room for development. There are, therefore, many points both financial and silvicultural for the removal and retention of suppressed and dominated stems in miscellaneous plantations and it must be left to the

Divisional Forest Officer to decide the policy for any one species in any one locality. The writer is of the opinion that whenever saleable, suppressed and badly dominated stems should be removed, and in the case of exotics such as *teak* and species like *gamar* which are prone to innumerable pests, they must be removed whether saleable or not. Also that in the first thinning of species put out in dense line-sowings, it is advisable to remove such stems in order to facilitate and ensure a better quality of thinning.

Density of thinnings.

Thinnings have in the past (up to 1933-34), especially with miscellaneous species, been done far too lightly. Species like *panisaj*, *utis*, (*Alnus nepalensis*), and *lampate* (*Duabanga sonneratoides*) require a heavy first thinning, otherwise they become long and spindly and the second thinning becomes very difficult owing to danger from wind-break. *Toon* (*Cedrela toona*), *chikrase* (*Chukrasia tabularis*) and *kainjal* (*Bischofia javanica*) do not require such a heavy thinning as their branches persist longer and a certain timber height must be obtained before crowns are opened out to any extent. With young *chañp* (*Michelia champaca*) and *malagiri* (*Cinnamomum cecidodaphne*) owing to the shape of their crowns gaps must be formed when trees are removed and thinning officers should not worry about this. The ideal is light and frequent thinnings but we cannot afford the men and money to follow out the little-and-often policy. When a thinning is done it must be heavy enough to last for the interval before the next thinning is due which means the crop will look very open just after a thinning has been carried out. It must be impressed on marking officers that a thinning so light that the canopy closes up in a year or so is a waste of time and money and increment of the crop

and a visit to a really heavily thinned plantation, a few years later is the best cure for a nervous thinning officer. We must however not go to the other extreme and it is just as bad forestry to overthin a plantation as to under-thin it, and the prior aim must be to obtain the maximum mean annual increment per acre consistent with the growth of timber of good quality. Between a stand of over-thinned park like trees and a dense unthinned stand there is a happy medium which is the object of all thinnings. Under-thinning leads to reduced crowns and arrested development and renders the crop as a whole incapable of putting on the highest possible increment per acre. Again under-thinning necessitates a longer rotation to produce timber of the desired girth and even five years added makes a considerable difference to the financial yield. Over-thinning, while possibly securing the highest possible increment per tree, does not allow of sufficient trees, being left to put on the highest possible increment per acre and tends to produce trees of inferior quality with short and many side branches. The aim of thinning must therefore be to allow a healthy development of the crown while at the same time retaining as many trees per acre as possible. In Europe, it is generally accepted that a thinning should be made of such an intensity that the canopy will close up within half the period between successive thinnings, and allow the struggle between individual trees in the second half of the period in order to encourage height growth and clean boles. The growth in Bengal is so very fast that the writer considers for species such as *sal*, *panisaj*, *pakasaj* (*Terminalia crenulata*), *toon chikrase*, *champ*, *malagiri* and *saur* (*Betula spp.*) two rains growing seasons in a five year interval and three years in a ten year interval in which to struggle is all that is necessary. This means that thinnings should be made so that the crop is closed up by the beginning of the fourth rains in a five year interval between

thinnings and by the seventh rains in a ten year period. With species which have a tendency to fork and branch, such as *jarut* (*Lagerstroemia flos-reginae*), *pipli* (*Bucklandia populnea*), *phalan* (*Quercus lineata*), and in a lesser degree *kainjal*, a height of say from forty to sixty feet should be obtained before the canopy is at all opened out, thinning at first should therefore be lighter than mentioned above and a longer period of struggle must be given. On the other hand it is considered that such species as *gamari*, *utis*, *lampati*, and *teak* thrive much better when crowns are kept slightly isolated, and with these species a thinning should be made sufficiently heavy to allow the canopy to close up only at the end of the period between thinnings.

After the Conservator of Forests' Inspection Note of February 1934 on the plantations of Buxa, Jalparguri, and lower parts of Kurseong and Kalimpong Divisions, a much heavier type of thinning has been carried out in all species. The Silviculturist while on tour made sample thinning for the Range Officers in different species of different ages in order to show the density of thinning which he considered was desirable in each case. A subsequent inspection of the thinning done by different Range Officers in these divisions showed that a great improvement has been made already, and even in some cases the thinnings in the opinion of the writer are on the heavy side (an unheard of thing before). This is again only a matter of opinion and time alone will only show. The rate of growth in Bengal is so rapid that the chief fault is usually under thinning. The number of stems per acre at different ages given in these notes are if anything on the conservative side, which has been done intentionally, but, as stated before, they only act as a guide and thinning officers must use their discretion as to whether more or less trees are to be taken out in any one case.

Age when thinnings should be carried out, type of thinnings, and interval between thinnings.

In a general note it is impossible to lay down at what age the first thinning in any one species should take place, as this depends far too much on localised conditions. Thinning schemes for the more important species have been drawn up for most working plans. Thinning schemes must not be looked upon as laying down a hard and fast rule as to when a species must be thinned. They only indicate when such and such a species is normally ready for thinning and also ensure that all plantations are inspected at certain regular intervals to see if they are fit for thinning. It is the officer on the spot, who by inspection only, can decide if any one species requires thinning earlier or later than that given in the thinning scheme.

With the majority of fast growing species, especially those raised from dense line sowings, thinning should never be delayed and should take place before the trees of the future have declared themselves naturally. Plantations left unthinned will undoubtedly declare their own dominants but not always where they are wanted and they are often of bad shape. Experiments have shown that in plantations where the first thinning has been delayed the trees of the future often occur in groups, and the number of good stems per acre is much less after thinning than where the first thinning has been done in time and trees of the future have been selected by the marking officers and not by nature. Again trees of the future naturally selected are quite often those that are forked, as having a bigger crown they grow faster and become wolf-trees, and if left too long they have so suppressed all the straighter trees around them that the marking officer has no option but to leave them. The foregoing shows the importance of not delaying the first thinning and the main points to attend to in a first thinning are an equal spacing of

selected straight stems by the removal, firstly, of all forked, badly shaped, diseased and wolf-stems, and, secondly, dominants of good shape so as to give the stems which are to remain full room for crown development. It must be emphasised that the object of this first thinning is not to favour the development of any single tree but to ensure as regular a spacing as possible of the remaining trees with full room, but not excessive room, for the development of their crowns. It is therefore important to remove trees that are bigger than the normal.

The second thinning which is normally carried out four or five years after the first should also not be delayed although if the first thinning has been well carried out the subsequent results of such delay may not be so bad as those of a delayed first thinning. Again spacing and the giving of room for normal crown development of selected straight stems by the removal of all forked, badly shaped, diseased and wolf-trees are the important points. After the second thinning, if the first two thinnings have been properly and timely carried out the crop should consist of evenly spaced straight stems with a space round each crown, and the third thinning both with *sal* and miscellaneous species in the plains should be heavy enough to last for a ten year period, as with our not inconsiderable annual increase in plantation area we cannot afford either the staff or money to continue at five year intervals. Therefore the third thinning should be very heavy if good growth is to be put on for the whole of this long interval.

Points to note in thinning.

Thinning in the plains should not be carried out in the rains, the best time being from November to February, or as long as the leaves are on the trees. In the hills however the most satisfactory time for

thinning appears to be in the rains. Neither in the hills or plains should thinning be done when trees are leafless.

As has already been explained in the first thinning the most important point is the equal spacing of selected straight stems of the future and to give them full room for development of their crowns.

~~of all "forks", forked, badly shaped, diseased stems, and in addition the removal of certain straight stems in order to give to the selected stems of the future sufficient room for the development of their crowns.~~ If forked trees have to be left as there are no straighter stems to take their place, then if the fork is under fifteen feet, it should be pruned. It is suggested that two coolies with a bamboo ladder should follow the thinning party to cut off such branches and the cost of say a rupee per day will be well repaid. Pruning should be carried out in the first and second thinnings when branches are small as it will then take little time. After the second thinning pruning is not feasible as it would be difficult and expensive. It cannot be too carefully impressed on thinning officers that the chief point about the tree is its shape and not its size, many ~~badly~~ shaped and forked trees are left as marking officers are loath to cut stems which have a larger girth than the others, and in this connection it must be remembered that, especially in first thinning, the larger stems are more often than not those that are forked as they have larger crowns and grow faster. Trees on the edge of a blank must be left. With miscellaneous species stems should be carefully examined for deer-damage and those that have been barked must be removed in preference to undamaged stems. Again certain species such as *toon* and *gamari* are liable to be attacked by *Loranthus* and such stems should also be removed whenever possible without creating too big a gap. Diseased stems must be removed in all cases.

It is extremely difficult to do a satisfactory thinning with species raised by dense line sowings unless suppressed and dominated stems are removed beforehand. A party of coolies should therefore work ahead of the thinning officer and remove all suppressed and badly dominated stems, this will give him a clear view of the ~~stems~~ of the dominant canopy and ensure a better thinning being done.

Species of less value are often to be found both in and between the lines, over-topping, or likely to over-top the principal species before the next thinning is due, these must be cut out. This is especially important in *sal* plantations where it was the practice to fill in small gaps with kainjal, jarul, etc. These should be cut out when small as if left, being faster growing, they become wolf-trees and besides suppressing good stems round about them cause a lot of damage to the principal crop when they are eventually felled. After a "C" or "D" grade thinning each dominant crown should have a complete space round it and no two crowns should be touching except in the case of trees on the edge of blanks. As previously explained, it must be clearly realised that crown development bears a definite relation to girth increment and if, after thinning, there is no room left for crown development, no appreciation girth increment can be expected.

The points to watch in the second and third thinnings are exactly those noted under the first thinning especially as regards spacing, and the removal of "wolf", forked, badly shaped, diseased, deer-damaged and *loranthus* attacked stems.

Thinning Staff.

It is not necessary to use the more senior subordinate for the younger thinnings. The first two thinnings in *sal* and say the first thinning in miscellaneous species

is comparatively simple, once the essential points have been carefully explained. These earlier thinnings should be marked by village *monda's*, guards, and especially intelligent coolies, who have spent most of their lives in the jungle and by instinct know a good deal about silviculture. They should be carefully taught by demonstration thinnings and when the instructing officer is satisfied that they understand what they have to do, they may safely be left to themselves. The only supervision which should then be necessary is inspection by a trained man who will remove any stems which, in his opinion, should not have been left. The third thinning in *sal* and second or third thinning with miscellaneous species is more difficult and such thinnings should be carried out by a more experienced hand.

Alnus nepalensis (*Utis*).—Planted at stake 6'×6'.

A fast growing light demander with a wide crown that requires plenty of room for development. It is impossible to lay down at what age the first thinning with this species should take place, as it is put out at so many different elevations and aspects, but as a general rule it will be ready for the first thinning in the fifth year. Thinnings, especially the first, should be not be delayed as this species when grown as a pure crop, does not show any real differentiation in the height of individual trees until after the tenth year, and runs up to a great height forming an even canopy with minute crowns, making thinning very difficult owing to the danger of damage from wind. The first thinning should be fairly heavy "C—D" grade, the object being the even spacing of selected dominants with full room for development of their crowns. The second and subsequent thinnings should be heavier than the first, a "D" grade, and must be sufficiently heavy to allow of the canopy only closing up in the year when the next thinning is due, as *utis* does not appear to thrive too well if crowns, even properly developed ones, are in too close a proximity to each other. Dominated and suppressed stems do not put on any increment, and when they reach this stage soon die out, so provided there is a demand, it is advisable to remove them in thinning before they disappear as

dry sticks. Trees are sometimes attacked by *loranthus* and such trees should be removed in thinnings whenever possible—

Species.	Age in years.	Number of dominant stems per acre after thinning.	Average height of dominant stems in feet.
<i>Ainus nepalensis</i>	5	320	34
	.6	285	38
	7	250	43
	8	225	46
	9	200	50
	10	190	55
	15	140	70
	20	110	84
	25	95	96

Note.—When put out in mixtures 12' \times 6' about 260 stems per acre will be left after thinning in the 5th year and about 165 after thinning in the 10th year.

Betula Spp. (Saur).—Planted at stake 6'×6'. There is little data for the treatment of this species in its younger stages. The crowns of young trees are much more conical than those of *utis* and consequently more trees per acre can be left after each of the earlier thinnings. Height growth is slower than *utis* at first, but after about the tenth year it is faster—

Species.	Age in years.	Number of dominant stems per acre after thinning.	Average height of dominant stems in feet.
Betula Spp.	5	510	30
	6	460	35
	7	410	40
	8	360	45
	9	325	50
	10	300	56
	15	210	80
	20	160	102
	25	130	120
	30	105	133
	35	90	142
	40	78	147

Bischofia javanica (Kainjal).—Planted at stake 6' × 6'. Growth is moderately fast in suitable localities. It is inclined to fork and branch when young and the first thinning should therefore be light, "B—C" grade, and confined to removal of badly shaped, diseased, forked, and wolf-trees, with the occasional removal of a poorly shaped dominant in the more congested patches. "By the tenth year a certain amount of timber height has been reached and the second thinning should be fairly heavy, "C—D" grade, as by this time the crowns will have become constricted and should be given more room for development. It has also been noticed that if crowns are not given enough room, the upper part of the stem becomes crooked and bent as the crowns reach towards any break in the canopy such as may occur when trees become dominated and fall out of the uppermost canopy. The third thinning should be a heavy "D" grade as the rate of growth is fast at this period and crowns must have considerable room for full development—

Species.	Age in years.	Number of dominant stems per acre after thinning.	Average height of dominant stems in feet.
Bischofia javanica	5	800	27
	6	790	30
	7	600	35
	8	500	40
	9	400	43
	10	320	46
	15	185	60
	20	155	.70

Bucklandia populnea (*Pipli*).—Growth is slow at first. This species must be grown close, as even if a slight break is made in the canopy the young trees will immediately fork and so in its younger stages no real opening of the canopy should be made: About the fifth year pruning should be carried out so as to leave one straight stem to each plant. Thinning is not needed until the tenth year in better areas, and fifteenth or longer in more unsuitable localities. First thinning should be very light "B" grade consisting chiefly of the removal of double stems and pruning of stems forked near the ground, and the only trees to be removed are "wolf-trees," diseased, and those stems badly shaped, or forked high up, which are over-topping straighter stems. No real opening up of the canopy should be made before a height of fifty to sixty feet is reached in about the thirtieth year. Thinnings previous to this should be very light "C—D" grade consisting of removal of wolf, badly shaped, and forked stems with the occasional removal of good shaped dominants in the more congested patches--

Species.	Age in years.	Number of dominant stems per acre after thinning.	Average height of dominant stems in feet.
Bucklandia populnea	10	860	27
	15	630	38
	20	500	49
	25	390	58
	30	300	67
	35	230	76
	40	185	83
	45	155	90
	50	140	97

Cedrela toona and microcarpa (Toon).—Dense line-sowing of pure *toon* of good growth may require thinning in the third or fourth year, and for "thalis" 6' x 6' in the fourth or fifth year. The first thinning should be a comparatively light "C" grade as if this species is opened out too much when young, it tends to branch, and thinning should be confined to the equal spacing of selected straight dominants by the removal of "wolf," badly shaped, diseased, and forked stems, and in addition the removal of good shaped dominants where the crowns are too congested and there is not enough room for the full development of the crowns of the selected stems. *Toon* is often attacked by *loranthus* and such trees should be removed in preference to others, if it is possible to do so without creating too big a gap in the canopy. Pruning of low forks and double stems is important and should be done at the same time as the first thinning as owing to attacks by the twig-borer it tends to be forked and branchy when young. Second thinning should be done exactly on the same lines as the first thinning but should be slightly heavier "C—D" grade which means that more of the straight dominants will be removed in order to give more room for the crown development of the remaining stems. Again, if trees with low forks have to be left as there are no straighter stems to take their place, they should be pruned. Third thinning should be heavy "D" grade, because besides extending the interval between thinnings to ten years, the growth at this age is extremely rapid, and having obtained a good length of clean bole increased girth increment is now required, which can only be obtained by increased crown development. Unlike *lampate*, *panisaj* and *amar*, dominated and suppressed stems for the most part persist and do not die back, but put on little growth. The question of leaving these stems is a matter of choice, but the writer is of the opinion that they should be removed

in the first thinning in plantations raised by dense line sowings in order to facilitate thinning and to ensure it being properly done—

Species.	Age in years.	Number of dominant stems per acre after thinning.	Average height of dominant stems in feet.
<i>Cedrela toona</i> and <i>Cedrela microcarpa.</i>	3	600	22
	4	460	27
	5	360	34
	6	300	40
	7	265	48
	8	240	54
	9	210	58
	10	200	63
	15	140	82
	20	100	98

Chukrasia tabularis (*Chikraser*).—The same treatment as for *Cedrela toona*. Its growth is not quite so rapid as that of *toon* and so a few more stems per acre can be left after each of the earlier thinnings—

Species.	Age in years.	Number of dominant stems per acre after thinning.	Average height of dominant stems in feet.
Chukrasia tabularis	.3	650	20
	4	520	26
	5	420	32
	6	350	38
	7	290	43
	8	250	47
	9	220	52
	10	205	56
	15	145	71
	20	115	83

Cinnamomum cecidodaphne (*malagiri*).—Planted at stake 6'×6'. Thinning is not usually required before the fifth or sixth year. The crown of this species is more conical than most of the other species put out in the plains and so more trees can be kept to the acre especially in the younger stages. First and second thinnings should be moderately heavy "C—D" grade and confined to the equal spacing of selected dominants by the removal of any forked, badly shaped, diseased, and wolf-trees, and in addition such good dominants as may be necessary to provide room for the normal crown development of the remaining stems. The third thinning should be heavy "D" grade: This species is often badly damaged by deer and trees so damaged should be removed in preference to other stems wherever possible—

Species.	Age in years.	Number of dominant stems per acre after thinning.	Average height of dominant stems in feet.
Cinnamomum cecidodaphne.	5	450	32
	6	410	37
	7	380	42
	8	350	46
	9	330	53
	10	310	59
	15	230	78
	20	200	90

Duabanga sonneratierioides (*Lampate*).—This species is extremely fast growing and first thinning is usually necessary in the third year. *Lampate*, owing to its horizontal (umbrella-shaped) method of branching, occupies a great deal of space and if the end of the twigs of one tree are allowed to rub against another, the young shoots die off and little or no increment is put on. All thinnings with this species should, therefore, be a heavy "D" grade and crowns must be kept slightly isolated which means that each thinning should be sufficiently heavy to allow the canopy to close up only at the end of the period between thinnings. Badly dominated and suppressed stems should be removed in thinning if saleable, as they cannot stand suppression and are found to die off as soon as they fall out of the top canopy. If grown for fuel only it is suggested that one heavy "D" grade thinning be done in the fourth or fifth year and then the crop left untouched until clear-felled.—

Species.	Age in years.	Number of dominant stems per acre after thinning.	Average height of dominant stems in feet.
Duabanga sonneratierioides.	3	530	29
	4	300	35
	5	250	40
	6	210	46
	7	180	51
	8	160	56
	9	145	61
	10	130	66
	15	90	90
	20	65	108

Gmelina arborea (*Gamar*).—A fast growing tree. If sown in lines thinning is required in the third year, and in "thalis" 6' × 6' in the fourth or fifth year. All thinnings with this species should be heavy "D" grade. It has a large round crown which should be kept well-separated as like *utis* it does not appear to thrive too well, if crowns, even properly developed, ones, are in close proximity to each other. So all thinnings should be made sufficiently heavy to allow the canopy to close up only at the end of the period between thinnings. The area will therefore look very open after thinning and there should be a clear space round each crown. *Gamar* is badly attacked by defoliators and *loranthus* and in both cases it has been noticed that if crowns are large and not at all restricted these attacks are not anywhere near as severe and serious as when the crowns are small and constricted. The following two instances are quoted to illustrate the advisability of heavy thinning in pure crops of *gamar* in order to create large crowns. At Kaptai in the Chittagong Hill Tracts Division one *gamar* plantation of a series was heavily thinned. In the following year there was a heavy attack by defoliators and the only plantation which was not entirely defoliated was the one that had been thinned. This plantation showed no signs of damage, the leaves being green and untouched, although surrounded by leafless plantations. Again in the 1924 Kaptai plantation, there was a very severe attack of *loranthus* that killed over sixty per cent. of the trees. Within this plantation, there was a sample plot which had been previously heavily thinned and it was found that not a single tree in the Sample Plot had been killed by the *loranthus*, and although it was present on some of the crowns they looked healthy and vigorous. This species is prone to so many diseases and pests such as defoliators, stem borers, fungus, etc., which may become epidemic, it is therefore essential to remove all suppres-

sed and dominated stems in each thinning as such trees are sickly and likely to be the cause of spreading many of these pests. *Loranthus* attacked trees should be removed in preference to others, if it is possible to do so without creating too big a gap in the canopy.—

Species.	Age in years.	Number of dominant stems per acre after thinning.	Average height of dominant stems in feet.
Gmelina arborea ..	3	550	28
	4	350	34
	5	275	42
	6	240	48
	7	215	52
	8	195	56
	9	175	60
	10	160	63
	15	110	77
	20	90	85

***Lagerstroemia flos-reginae* and *hypoleuca* (Jarul).—**

This species has an extremely bad habit of branching and must be kept close for several years until about fifty to sixty feet in height is obtained. When sown at stake $4' \times 4'$ the first thinning is usually required in the eighth year, which should be a very light "B" grade and is more of an improvement marking than a real thinning, and only very badly low-forked, diseased, big wolf, or leaning trees interfering with the growth of better stems are removed, and no thinning amongst the well-shaped stems is done. Suppressed and dominated stems are kept. The second thinning in the thirteenth year should be a comparatively light "C—D" grade, and even spacing of selected dominants should be done by the removal of all badly forked, "wolf," diseased, and badly-shaped stems, and in addition some good dominants in order to give room for crown development of the selected stems. Pruning of low forks should be done at the time of second thinning. The third thinning should be a heavy "D" grade. No plots have been laid out in the very dense line sowings that are now the practice in Northern Bengal but judging from one or two samples done, the first thinning is required in the third or fourth year and the spacing of selected stems should be about three to four feet apart in order to relieve congestion in the lines and also to eliminate root competition to a certain extent.

The second and third thinning will then take place in the eighth and thirteenth year exactly as explained

above for the first and second thinning when sown in "thalis" 4' × 4'.—

Species.	Age in years.	Number of dominant stems per acre after thinning.	Average height of dominant stems in feet.
<i>Lagerstroemia flos-reginae</i> and	8	760	42
	9	450	46
<i>Lagerstroemia hypoleuca.</i>	10	380	50
	11	340	54
	12	310	57
	13	285	59
	14	260	62
	15	240	65
	20	175	77

Michelia champaca (*Chāñp*).—This species grows fast and straight and by its method of branching keeps a clean bole even when isolated and so there is no need to keep trees especially close in order to develop clean boles. Planted at stake 6' × 6', thinning is not usually required before the fifth year. The first thinning should be a fairly heavy "C—D" grade. The sec'nd and subsequent thinnings will be a heavier "D" grade, but as its crown is inclined to be conical there will be more trees per acre left after thinning than is the case with such species as *gamar* and *lampate* whose crowns are more spreading. Thinnings will aim at the equal spacing of selected dominants by the removal of wolf, badly shaped, diseased, forked trees, and in addition certain good dominants in order to give room for full crown development for the selected stems. Trees that have been barked by deer or badly attacked by the pest *Urostylis punctigera* should be removed whenever possible. Again in some plantations a fair number of noticeably large wolf trees occur, these should also be removed if it is possible to do so without making too big a gap.—

Species.	Age in years.	Number of dominant stems per acre after thinning.	Average height of dominant stems in feet.
Michelia champaca	5	400	30
	6	350	35
	7	300	40
	8	270	44
	9	240	49
	10	220	53
	15	150	71
	20	120	81

Quercus lineata (Phalaen).—Growth is slow at first but from the fifteenth year is quite fast. Pruning of double stems and forks should be carried out between sixth to eighth year. The first thinning is not necessary until the fifteenth year. It should be a very light "B" grade and consist of the removal of wolf, diseased, badly forked and mis-shapen trees only and it should not be necessary to remove any well shaped stems. Pruning of low forks should be done at the time of the first thinning. Second and subsequent thinnings should be a comparatively light "C" grade, the object being an even spacing of selected dominants by the removal of wolf, forked, diseased, and badly shaped stems, with an occasional good dominant in order to give room for the proper crown development of the selected dominants.—

Species.	Age in years.	Number of dominant stems per acre after thinning.	Average height of dominant stems in feet.
Quercus lineata ..	15	1,020	32
	20	760	42
	25	600	52
	30	490	60
	35	395	68
	40	335	75

Shorea robusta (Sal).—*Sal* of average growth is ready for first thinning in the fifth year, that is in its sixth cold-weather, second and third thinnings will take place after an interval of five years. The third thinning should be heavy enough to last for a ten year interval as it is impossible with our present staff to continue thinning indefinitely at five-year intervals. The first thinning must not be delayed and should be carried out before the dominant stems declare themselves naturally. Actual experiments have proved that if thinning is delayed, dominants, more often than not, appear in groups. Statistics have shown that there are many more good stems per acre in a plantation that has been thinned when due for thinning than in a plantation in which thinning has been delayed. In other words, if the dominants have been selected by the thinning officer more good stems per acre are obtained than if nature had been allowed to select them. Again it was found that natural dominants are more often than not forked, as these stems having bigger crowns get ahead and suppress the straight stems, and if thinning is delayed they have become so well established and have suppressed everything round them that there is no option but to leave them.

The first thinning should therefore be a fairly heavy "C—D" grade and should take place before dominants have actually declared themselves, and will consist of an equal spacing of selected straight stems, by the removal first of all of wolf, forked, diseased and badly-shaped stems, and in addition occasional good stems in order to give sufficient room for the crown development of the remaining stems. It appears that in a plantation of average growth eighteen to twenty-two stems are left to every hundred feet of line that is four to six feet apart, but this of course depends on the height of the trees, more trees being left when the height-growth is less than the average and vice-versa. It has been noticed that there is a tendency to thin too heavily

when height growth is poor and too light when height growth is good, therefore the height of the trees in any part of a line should be carefully studied before thinning is done, and the spacing of the stems adjusted accordingly. As an indication of the spacing between crowns the writer always tries to leave them so that the top of the crowns will just touch when blown by a slight breeze. For reasons, previously discussed, the present orders are, that all dominated and suppressed stems must be removed in thinning, and coolies should work ahead of the marking officer and remove all suppressed and dominated stems that must obviously be removed, as this will facilitate the work and make thinning easier and better. It is extremely difficult to do a satisfactory thinning in dense line sown *sal* unless these stems are cut first, as it is then only possible to get a clear view of the stems in the dominant canopy. Trees on the edge of a blank must be left. All miscellaneous species such as *kainjal*, *jarul* used to fill up gaps, and *goehlo* (*Callicarpa arborea*), *kadam* (*Anthocephalus indicus*), *mallata* (*Macaranga* and *Mallotus spp.*), etc., that come up naturally between the lines, which are over-topping or likely to over-top the *sal* before the next thinning is due, should also be removed. This is often lost sight of with consequent damage to the crop when they are removed later as wolf trees. In young *sal* many trees are found to be forked most probably due to previous damage by climbers and it must be impressed on all marking officers that such trees should be removed whenever possible, as having two crowns, they grow faster than the straighter stems, and if left will get bigger and bigger and suppress all straight stems in their vicinity. If it is impossible to remove such forked stems as there are no straighter stems to take their place they should be pruned to a height of about fifteen feet. If the thinnings are not saleable felling of stems may be done at a convenient height so as to facilitate

work, but if saleable should be felled as low as possible. The second thinning should again be a fairly heavy "C—D" grade and the points to note are exactly the same as for the first thinning. The third thinning should be heavier, a "D" grade as the aim should be to make it last for a ten instead of five year period. There is one further point, it has been noticed lately that in some plantations, trees of all canopy classes from healthy dominants down to suppressed stems, have been attacked by something that causes a swelling of the stem, the bark of which eventually falls off exposing dead wood. The full effect of this damage is not known, but this disease should be watched for and such stems should be removed whenever possible without creating a permanent gap.

Burning is carried out annually in *sal* plantations from the eighth year onwards and it must be clearly understood that burning should be never be done in the same year that a plantation has been thinned, as with the extra "slash" on the ground the fire will be too strong and plantations may be badly damaged.—

Species.	Age in years.	Number of dominant stems per acre after thinning.	Average height of dominant stems in feet.
<i>Shorea robusta</i> ..	5	1,450	20
	6	1,200	24
	7	1,000	27
	8	850	30
	9	650	34
	10	550	38
	15	330	56
	20	240	72
	25	190	83
	30	150	92

and diseased trees, and in addition, certain good dominants in order to give full room for the development of the crowns of the selected trees. Trees on the edge, of a blank should be left. Trees of abnormally large growth often occur, these should be removed as the object is not to favour the development of any single tree but to get an even spacing of straight stems of normal growth. With *teak* all dominated and suppressed stems must be removed in all thinnings as, besides being an exotic, it suffers from so many pests and diseases which may become epidemic, these are usually spread from trees that have not full room for development and are consequently sickly. Thinning should not be done before November or after the rains have commenced, the best time being between November and February when the trees are in full leaf. Subsequent thinnings will take place at intervals of five years. The second thinning will be fairly heavy "D" grade and the points to remember are exactly the same as those mentioned for the first thinning, that is, the even spacing of selected straight stems by the removal of badly cankered, wolf, forked, diseased, and misshapen stems and in addition the removal of good dominants in order to give room for full crown development of the remaining stems. "

The third thinning should be a very heavy "D" grade as trees have by then reached a good timber height and the object now will be to obtain an increased rate of diameter increment, if this is not done trees

become very tall and spindly and there will be danger from damage by wind—

Species.	Age in years.	Number of dominant stems per acre after thinnings.	Average height of dominant stems in feet.
Tectona grandis . .	5	470	34
	6	375	40
	7	330	46
	8	300	51
	9	275	55
	10	240	60
	15	160	80
	20	125	97
	25	105	106
	30	90	110
	35	80	113
	40	70	116
	45	65	118
	50	58	119
	55	52	120
		•	

Terminalia crenulata (Pakasaj).—Dense line-sowings of good growth may require thinning in the third or certainly not later than in the fourth year. When sown in thalis 6'×6', it requires thinning in the fourth or fifth year. This species differs from *panisaj* in that the frondose habit of growth is not so marked, also being more tolerant of shade stems do not tend to lean over each other in order to reach a break in the canopy. Consequently more stems can be left per acre than with *panisaj* as it is not necessary to open out the canopy so much in order to get the stems to straighten up and come over to the more radially symmetrical habit of growth. First thinning should be moderately heavy "C—D" grade and consist of the even spacing of selected stems by removal of any wolf, forked, diseased, or badly shaped stems and in addition occasional straight dominants in order to give full room for the crown development of the selected stems. It has been noticed that trees of abnormally large growth are to be found quite frequently, these should be removed before they become too big as if left they become very branchy and suppress stems of smaller but straighter growth. The second thinning should be heavier, a "D" grade, and the points to attend to are the same as mentioned for the first thinning. The third thinning should be a still heavier "D" grade, as this species puts on a lot of growth during this period and plenty of room is required for full crown development. Dominated and suppressed stems should be removed

in the first thinning in plantations raised by dense line sowings in order to facilitate and ensure a better quality of thinning. Their removal in subsequent thinnings is a matter of opinion but the writer considers it advisable to remove them when saleable as they put on little growth and will only die and disappear—

Species.	Age in years.	Number of dominant stems per acre after thinning.	Average height of dominant stems in feet.
Terminalia crenulata	3	700	26
	4	530	34
	5	440	40
	6	370	45
	7	310	50
	8	260	54
	9	230	59
	10	200	62
	15	150	77
	20	125	87

Terminalia myriocarpa (*Panisaj*).—The young tree has the frondose habit of growth more marked than those of the 'other' *Terminalias* and *Lagerstroemias* and is also rather inclined to fork and branch, and so it is a question of deciding the best stage at which to give the crowns more room to go over to their more radially symmetrical habit. If thinning is postponed the crowns remain narrow and lean over their neighbours and it may be questioned whether their response to late thinning would be satisfactory and quick. If thinning is done too early, low branching may persist. *Panisaj* is extremely light demanding and stems lean over each other in order to get even a tip of their crowns into the dominant canopy, and in congested areas, stems are to be found leaning in all directions making thinning extremely difficult as it is hard to judge exactly where stems will straighten up to on opening up the canopy. The writer considers that an overdue thinning in congested *panisaj* is the most difficult thinning there is, and experiments have proved that after thinning there are many more straight stems per acre in plantations that have been thinned in time, than where they have become congested and dominants have been allowed to declare themselves naturally. Further, crowns will remain narrow and frondose and stems will not straighten up unless they have a lot of room for development. For the above reasons it is the opinion of the writer that the first thinning should, therefore, be carried out *before* the natural selection of dominants have taken place, and experience has shown that dense line sowings of *panisaj* of good growth requires thinning in the third or fourth year, on the more sandy sites in parts of the Kalimpong Foot Hills in the fifth or sixth year. The first thinning should be a heavy "C—D" grade and will consist of the even-spacing of selected dominants by the removal of all badly shaped, wolf, diseased, and forked stems; and in addition the removal of good dominants so as

to give the selected stems room for proper crown development. As explained above stems bend over in all directions in order to get a place however small for the tips of their crowns in the dominant canopy, and in thinning great care must be taken to see that the crowns of the selected stems are so given room that they can straighten up and develop their radially symmetrical adult habit of growth. Thinning, therefore, *must* be done for the benefit of the crowns as they stand at the time of thinning, or stems will not straighten up and will continue to grow at an angle. Low forked and branched stems which have to be left, as there are no straighter stems to take their place should be pruned at the time of the first thinning. The second and third thinnings should be a heavy "D" grade as the species is very fast growing and being extremely light demanding crowns are intolerant of constriction. Measurements show that mature crowns of *panisaj* are the largest of our plantation species even more so than *lampati* and so the stems must be widely spaced in order to have full room for crown development. Subsequent thinnings will consist of the removal of an occasional pole in congested patches. As regards removal of suppressed and dominated stems, sample plots show that if stems are even the very slightest bit suppressed they put on no increment, and those falling out of the top canopy soon die off, such trees must be very sickly and only encourage pests. The writer is of the opinion that dominated and suppressed stems should be removed, especially in the first thinnings with dense line sowings in order to facilitate thinning and to ensure it being properly done. The practice now is to raise *panisaj* and *chikrase* in mixed line sowings, the *chikrase* being used as the understorey to the light canopied *panisaj*. In the first thinning in mixed line sowings the *chikrase* should not be touched except where there happens to be no *panisaj*, and in such places thinning of

chikrase should be carried out for the benefit of selected stems and it should be treated exactly as if it were *panisaj*. The understorey of *chikrase* may require a very light thinning in the second and subsequent thinnings—

Species.	Age in years.	Number of dominant stems per acre after thinning.	Average height of dominant stems in feet.
Terminalia myriocarpa	3	500	20
	4	340	26
	5	270	32
	6	240	38
	7	210	42
	8	190	47
	9	170	52
	10	155	56
	15	115	71
	20	90	81

**Table giving the number of trees per acre at
different spacing in multiples of 4' and 6'.**

Table giving the number of trees per acre at different spacing in multiples of 4' and 6'.

Spacing.	No. of trees.	Spacing.	No. of trees.	Spacing.	No. of trees.	Spacing.	No. of trees.
4' × 1'	10,890	6' × 1'	7,260	8' × 1'	5,445	12' × 1'	3,630
4' × 2'	5,445	6' × 2'	3,630	8' × 2'	2,722	12' × 2'	1,815
4' × 3'	3,630	6' × 3'	2,420	8' × 3'	1,815	12' × 3'	1,210
4' × 4'	2,722	6' × 4'	1,815	8' × 4'	1,361	12' × 4'	907
4' × 5'	2,178	6' × 5'	1,452	8' × 5'	1,089	12' × 5'	726
4' × 6'	1,815	6' × 6'	1,210	8' × 6'	907	12' × 6'	605
4' × 7'	1,555	6' × 7'	1,037	8' × 7'	777	12' × 7'	518
4' × 8'	1,361	6' × 8'	907	8' × 8'	680	12' × 8'	453
4' × 9'	1,210	6' × 9'	806	8' × 9'	605	12' × 9'	403
4' × 10'	1,089	6' × 10'	726	8' × 10'	544	12' × 10'	363
4' × 11'	990	6' × 11'	660	8' × 11'	495	12' × 11'	330
4' × 12'	907	6' × 12'	605	8' × 12'	453	12' × 12'	302
4' × 13'	837	6' × 13'	558	8' × 13'	418	12' × 13'	279
4' × 14'	777	6' × 14'	518	8' × 14'	388	12' × 14'	259
4' × 15'	726	6' × 15'	484	8' × 15'	363	12' × 15'	242
4' × 16'	680	6' × 16'	453	8' × 16'	340	12' × 16'	226
4' × 17'	640	6' × 17'	427	8' × 17'	320	12' × 17'	213
4' × 18'	605	6' × 18'	403	8' × 18'	302	12' × 18'	201
4' × 19'	573	6' × 19'	382	8' × 19'	286	12' × 19'	191
4' × 20'	544	6' × 20'	363	8' × 20'	272	12' × 20'	181
4' × 21'	518	6' × 21'	345	8' × 21'	259	12' × 21'	172
4' × 22'	495	6' × 22'	330	8' × 22'	247	12' × 22'	165

4' × 23'	473	6' × 23'	315	8' × 23'	236	12' × 23'	157
4' × 24'	463	6' × 24'	302	8' × 24'	226	12' × 24'	151
4' × 25'	435	6' × 25'	290	8' × 25'	227	12' × 25'	145
4' × 26'	418	6' × 26'	279	8' × 26'	209	12' × 26'	139
4' × 27'	403	6' × 27'	268	8' × 27'	201	12' × 27'	134
4' × 28'	388	6' × 28'	259	8' × 28'	194	12' × 28'	129
4' × 29'	375	6' × 29'	250	8' × 29'	187	12' × 29'	125
4' × 30'	363	6' × 30'	242	8' × 30'	181	12' × 30'	121
4' × 31'	351	6' × 31'	234	8' × 31'	176	12' × 31'	117
4' × 32'	340	6' × 32'	226	8' × 32'	170	12' × 32'	113
4' × 33'	330	6' × 33'	220	8' × 33'	165	12' × 33'	110
4' × 34'	320	6' × 34'	213	8' × 34'	160	12' × 34'	106
4' × 35'	311	6' × 35'	207	8' × 35'	155	12' × 35'	103
4' × 36'	302	6' × 36'	201	8' × 36'	151	12' × 36'	100

Spacing.	No. of trees.						
16' × 1'	2,722	18' × 1'	2,420	20' × 1'	2,178	24' × 1'	1,815
16' × 2'	1,361	18' × 2'	1,210	20' × 2'	1,089	24' × 2'	907
16' × 3'	907	18' × 3'	866	20' × 3'	726	24' × 3'	605
16' × 4'	680	18' × 4'	605	20' × 4'	544	24' × 4'	453
16' × 5'	544	18' × 5'	484	20' × 5'	435	24' × 5'	363
16' × 6'	453	18' × 6'	403	20' × 6'	363	24' × 6'	302
16' × 7'	388	18' × 7'	345	20' × 7'	311	24' × 7'	259
16' × 8'	340	18' × 8'	302	20' × 8'	272	24' × 8'	226
16' × 9'	302	18' × 9'	268	20' × 9'	242	24' × 9'	201
16' × 10'	272	18' × 10'	242	20' × 10'	217	24' × 10'	181
16' × 11'	247	18' × 11'	220	20' × 11'	198	24' × 11'	165
16' × 12'	226	18' × 12'	201	20' × 12'	181	24' × 12'	151
16' × 13'	209	18' × 13'	186	20' × 13'	167	24' × 13'	139
16' × 14'	194	18' × 14'	172	20' × 14'	155	24' × 14'	129
16' × 15'	181	18' × 15'	161	20' × 15'	145	24' × 15'	121
16' × 16'	170	18' × 16'	151	20' × 16'	136	24' × 16'	113
16' × 17'	160	18' × 17'	142	20' × 17'	128	24' × 17'	106
16' × 18'	151	18' × 18'	134	20' × 18'	121	24' × 18'	100
16' × 19'	143	18' × 19'	127	20' × 19'	114	24' × 19'	95
16' × 20'	136	18' × 20'	121	20' × 20'	108	24' × 20'	90
16' × 21'	129	18' × 21'	115	20' × 21'	103	24' × 21'	86
16' × 22'	123	18' × 22'	110	20' × 22'	99	24' × 22'	82
16' × 23'	118	18' × 23'	105	20' × 23'	94	24' × 23'	78
16' × 24'	113	18' × 24'	100	20' × 24'	90	24' × 24'	75
16' × 25'	108	18' × 25'	96	20' × 25'	37	24' × 25'	72

16' × 26'	104	18' × 26'	93	20' × 26'	93	24' × 26'	93	24' × 26'
16' × 27'	100	18' × 27'	89	20' × 27'	89	24' × 27'	70	24' × 27'
16' × 28'	97	18' × 28'	86	20' × 28'	86	24' × 28'	77	24' × 28'
16' × 29'	93	18' × 29'	83	20' × 29'	83	24' × 29'	75	24' × 29'
16' × 30'	90	18' × 30'	80	20' × 30'	80	24' × 30'	72	24' × 30'
16' × 31'	87	18' × 31'	78	20' × 31'	78	24' × 31'	70	24' × 31'
16' × 32'	85	18' × 32'	75	20' × 32'	75	24' × 32'	68	24' × 32'
16' × 33'	83	18' × 33'	73	20' × 33'	73	24' × 33'	66	24' × 33'
16' × 34'	80	18' × 34'	71	20' × 34'	71	24' × 34'	64	24' × 34'
16' × 35'	77	18' × 35'	69	20' × 35'	69	24' × 35'	62	24' × 35'
16' × 36'	75	18' × 36'	67	20' × 36'	67	24' × 36'	60	24' × 36'

No. of trees.	Spacing.	No. of trees.	Spacing.	No. of trees.
1,555	32' x 1'	1,361	36' x 1'	1,210
777	32' x 2'	680	36' x 2'	605
618	32' x 3'	453	36' x 3'	• 403
28' x 4'	32' x 4'	388	36' x 4'	302
28' x 5'	32' x 5'	311	36' x 5'	242
28' x 6'	32' x 6'	259	36' x 6'	201
28' x 7'	32' x 7'	222	36' x 7'	172
28' x 8'	32' x 8'	194	36' x 8'	151
28' x 9'	32' x 9'	172	36' x 9'	134
28' x 10'	32' x 10'	155	36' x 10'	121
28' x 11'	32' x 11'	141	36' x 11'	110
28' x 12'	32' x 12'	129	36' x 12'	100
28' x 13'	32' x 13'	119	36' x 13'	93
28' x 14'	32' x 14'	111	36' x 14'	86
28' x 15'	32' x 15'	103	36' x 15'	80
28' x 16'	32' x 16'	97	36' x 16'	75
28' x 17'	32' x 17'	91	36' x 17'	71
28' x 18'	32' x 18'	86	36' x 18'	67
28' x 19'	32' x 19'	81	36' x 19'	63
28' x 20'	32' x 20'	77	36' x 20'	60
28' x 21'	32' x 21'	74	36' x 21'	57
28' x 22'	32' x 22'	70	36' x 22'	55
28' x 23'	32' x 23'	67	36' x 23'	52
28' x 24'	32' x 24'	64	36' x 24'	50
28' x 25'	32' x 25'	62	36' x 25'	48

28' x 26'	59	32' x 26'	52	36' x 27'	46
28' x 27'	57	32' x 27'	50	36' x 27'	44
28' x 28'	55	32' x 28'	48	36' x 28'	43
28' x 29'	53	32' x 29'	46	36' x 29'	41
28' x 30'	51	32' x 30'	45	36' x 30'	40
28' x 31'	50	32' x 31'	43	36' x 31'	39
28' x 32'	48	32' x 32'	42	36' x 32'	37
28' x 33'	47	32' x 33'	41	36' x 33'	36
28' x 34'	45	32' x 34'	40	36' x 34'	35
28' x 35'	44	32' x 35'	38	36' x 35'	34
28' x 36'	43	32' x 36'	37	36' x 36'	33

